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(54) Title: GEL COMPOSITIONS

(57) Abstract: The invention relates to a composition which comprises a dispersion of micro spheres in a gel comprising an oily base and an organic polymeric gelling agent.

GEL COMPOSITIONS

This invention relates to gel compositions for filling cables, such as communication cables, in particular to gel compositions containing micro spheres, and to methods of preparing such gels.

Background of the Invention

Communications cables typically comprise a signal-conducting core surrounded by a protective sheath. The core can, for example, conduct light signals or electrical signals. In many cables the space between the conductor and sheath contains a filler, the role of which is to protect and cushion the core from external forces that might be produced by, for example, bending or coiling, particularly in the case of fibre-optic cables. A further role of the filler is the prevention of water ingress which is particularly pertinent should the core comprise a metal such as copper. In order to fulfil these requirements, the filler must display a number of characteristics. The filler must be of sufficient viscosity in order to allow lateral movement of the core which occurs during, for example, bending, coiling or laying. The viscosity must however not be so low as to allow a drip wise loss of filler during vertical laying of cables. Moreover, this balance of properties must be maintained over a temperature range of -40 to +80°C. The filler must be formulated to be chemically compatible with cable grade polymers, which includes not only the cable sheath but also coatings typically found on optical fibres. The filler should also show a high degree of elasticity in order to absorb the force of impacts that the cable sheath may undergo during its operating lifetime. Relatively high ambient temperatures can be reached through fabrication of such cables resulting in thermal expansion of the filler which then leads to the formation of holes and cavities on cooling. Such holes and cavities can potentially become a water path which in fibre optic cables can lead to attenuation of the light wave guide. Thus cable fillers should ideally show low thermal conductivity. For electrical applications or cores transmitting electrical signals, it is advantageous if the filler has a low permittivity thus insulating the conducting core. This has the additional benefit of rendering the filler hydrophobic thereby protecting the core from water ingress. The anti-drip resistance of fillers can be improved by reducing their specific weight. Finally, for easy handling, it is preferred if the filler is semi-dry to the touch, rather than sticky.

Existing fillers used in telecommunication cables include oil gels which are primarily blends of oils and gelling agents. In application, they penetrate between bundles of, for

example, densely packed insulated copper conductors and in so doing insulate them from moisture. The oil, which comprises a major part of the blend, can be a naphthenic or paraffinic processing oil, a mineral oil, a synthetic product such as a polybutane or a silicone oil. Gelling agents include waxes, silicic (silica gels) acids, fumed silica, fatty acid soaps and thermoplastic elastomers. Typically the gelling agent comprises less than 10% of the whole.

One particular family of thermoplastic elastomers marketed under the trade mark 'Kraton' (Shell Chemical Company), comprises di-block, tri-block or multi-arm molecular configurations of rubber and polystyrene segments.

US 5 657 410 describes an optical transmission element which includes a filler comprising between 80% and 95% by weight of a monomeric plasticizer having a molecular weight in the range 200-2000 grams per mole. Such monomeric plasticizers include esters of phthalates, trimellitates, phosphates and fatty esters. Additional substances may also be added such as thickeners. The thickener can take the form of small spheres. Hollow spheres are preferred due to their great compressibility and easy processibility. Thixotropic agents may also advantageously be added. They include finely divided or fumed silica, alumina, and bentonites as well as mixtures of these substances.

The use of micro spheres, e.g. hollow micro spheres, in cable filling compounds is also described in US 5 698 615. In this disclosure the cable filler comprises a substantially dry hydrophilic composition containing *inter alia*, in addition to the micro spheres, water absorbent swellable powder particles, preferably of particle size range 1-30 μm and a "parting powder" having particles of preferably 1/100th the size of the swellable powder particles. Due to the hydrophilic nature of the swellable powder particles, the composition always retains some water. The parting powder particles are disposed between the swellable powder particles to prevent agglomeration as the swellable polymer particles absorb water. Suitable swellable powder particles are those based on the polyacrylic acid sodium salt. The parting powder particles are typically inorganic powders such as talcum, mica, graphite and silicates. The absorption of water by the swellable powder particles transforms the dry composition into a gel which seals the core from further water ingress. The compositions can also contain a small amount of an oil or an adhesive to reduce any potential dust hazard.

WO 99/15582 discloses a composition which includes expandable hollow micro spheres

for use in encapsulation of for example semi-conductor chips. Such hollow micro spheres, similar in morphology to the micro spheres disclosed in US 5 657 410 and US 5 698 615, comprise a polymeric shell encapsulating a blowing agent. When heated, the polymeric shell of the expandable micro spheres gradually softens and the liquid blowing agent, typically isobutane, starts to evaporate thus expanding the microsphere.

A light wave guide lead is disclosed in US 5 335 302 which comprises at least one light wave guide accommodated in a protective sheath and embedded in a pasty filling material containing small micro spheres. The small micro spheres, which can be solid and rigid, solid and elastic or hollow and elastic, are included as fillers to reduce the cost, and to provide improved rheological and cushioning properties. A preferred filler comprises an oil, a thixotropic agent (for example fumed silica) and an unspecified organic thickener.

Summary of the Invention

In one aspect, the present invention provides a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and an organic polymeric gelling agent.

In another aspect, the invention provides a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and an organic polymeric gelling agent, the composition containing substantially no thixotropic agent other than the organic polymeric gelling agent.

In a further aspect, the invention provides a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and a polymeric gelling agent wherein the polymeric gelling agent comprises, consists essentially of, or consists of a thermoplastic elastomer.

Another aspect of the invention provides a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and a polymeric gelling agent wherein the polymeric gelling agent comprises, consists essentially of, or consists of a thermoplastic elastomer other than polystyrene-isoprene rubber.

Yet another aspect of the invention provides a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and a polymeric gelling agent wherein the polymeric gelling agent comprises, consists essentially of, or consists of a thermoplastic elastomer, excluding
5 compositions containing polystyrene-isoprene rubber and an organic thickener.

A further aspect of the invention provides a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and a thermoplastic elastomer as a gelling agent, the composition
10 containing substantially no thixotropic agent in addition to the thermoplastic elastomer.

Another aspect of the present invention is a gel composition comprising a dispersion of organic microspheres in a gel comprising an oily base and a thermoplastic elastomer, the gel containing substantially no thixotropic agent in addition to the thermoplastic elastomer and
15 being substantially free from silica, for example fumed silica.

A particular embodiment of the invention is a composition, particularly a composition suitable for use as a cable filler, which comprises a dispersion of micro spheres in a gel comprising an oily base and an organic polymeric gelling agent wherein the gel is substantially
20 free of fumed silica.

The gels of the invention may additionally contain an anti-oxidant.

The oily base can comprise a hydrocarbon oil or a silicone oil. Particularly preferred
25 hydrocarbon oils include white mineral oils and poly(α -olefin) synthetic oils. The oily base typically constitutes 1-99% by weight of the gel, more preferably 50-99% by weight of the gel, in particular 80-99% by weight of the gel.

Examples of thermoplastic elastomers include thermoplastic rubbers. The thermoplastic
30 elastomer can be a copolymer, for example a block copolymer possessing a di-block, a tri-block, or a multi-arm molecular configuration. In one particular embodiment, the blocks are comprised of either rubber or polystyrene. The rubber can be a saturated olefin rubber composed of ethylene, propylene or butylene monomer units. Alternatively, the rubber can be an unsaturated olefin rubber comprising butadiene or isoprene monomer units.

Particular examples of thermoplastic elastomers include styrene-ethylene/butylene styrene tri-block copolymer (SEBS), styrene-ethylene/propylene di-block copolymer (SEP), ethylene/propylene multi-arm copolymer (EP), styrene-butadiene-styrene tri-block copolymer (SBS) and styrene-isoprene-styrene tri-block copolymer (SIS).

Commercially available thermoplastic elastomers include the copolymers available under the trade mark "Kraton" from Shell.

The polymeric gelling agent is typically used in proportions in the range 1-10% by weight of the composition, more preferably, in the range 2-9% by weight of the composition, in particular in the range 3-8% by weight of the composition.

The micro spheres can be, for example, solid rigid micro spheres, solid elastic micro spheres or compressible hollow micro spheres. Solid rigid micro spheres can be formed from a thermosetting resin such as melamine-formaldehyde resin which has a relatively low thermal expansion coefficient and in use would tend to lower the overall expansion coefficient of the gel. This is particularly advantageous where the gel may be heated during manufacture of, for example, fibre optic leads. During such processes, conventional materials tend to expand when heated leaving holes or cavities around the wave guides on cooling. The holes or cavities can, under certain conditions, lead to an increase in attenuation of the light wave guides. The melamine-formaldehyde micro spheres, available from Ubitek Company of Uchte, preferably have a diameter of $< 10\mu\text{m}$, in particular $< 1\mu\text{m}$.

Examples of solid elastic micro spheres are those comprising polyisoprene. The polyisoprene is not only elastic in its own right but can additionally absorb considerable quantities of the oily base thereby becoming even more elastic. The mean diameter of the micro spheres is preferably $< 10\mu\text{m}$, more preferably $< 1\mu\text{m}$.

One preferred embodiment of the invention uses compressible hollow micro spheres each comprising a polymeric shell encapsulating a blowing agent. The polymeric shell is generally formed from a copolymer, for example a copolymer of vinylidene chloride and acrylonitrile. The blowing agent can, for example, be isobutane or isopentane. In addition, the micro spheres can be expanded or unexpanded. The polymeric shell of the unexpanded micro spheres softens on heating, so allowing the evaporating blowing agent to expand the volume of the micro

spheres.

Such hollow micro spheres whether expanded or initially unexpanded, display a high degree of elasticity and additionally have a low specific weight. Use of such micro spheres in the gels disclosed in this invention is advantageous in that they lower the overall specific weight of the gels and thus reduce or eliminate drip-out during vertical laying of the cable.

The hollow nature of the micro spheres means that the proportion of solid material is very low relative to the volume. Thus their addition to the gels of the invention leads to a reduction in the overall thermal conductivity and a reduced likelihood of decomposition of any of the components of the gel or the creation of voids under the elevated temperatures reached during cable manufacture. The superior elastic properties of the hollow micro spheres over their solid counterparts gives improved protection to, for example, light wave guides during conveying, coiling or laying. Additionally, the problem of attenuation of light waveguides due to the presence of holes or cavities within the cable filling is also reduced as any increase in volume of the bulk of the filler due to heating during cable manufacture is matched by a converse reduction in the volume of the hollow micro spheres. Due to the compressible nature of such hollow micro spheres, their typical diameters are greater than those of their solid counterparts. In fibre optic cable applications, diameters in the range of the diameter of the light wave guide can be used. For expanded hollow micro spheres, the diameters will typically lie in the range 1-200 μm , more usually less than 100 μm , typically less than 75 μm , for example 15 to 55 μm . For unexpanded hollow micro spheres, the mean diameter prior to expansion is typically in the range up to 50 μm , more usually less than 30 μm , for example in the range 10 to 20 μm .

The volume proportion of the micro spheres generally differs for solid and hollow counterparts. The solid micro spheres are typically employed in the volume range 1-50% by volume of the gel (v/v), more preferably in the range 5-50% v/v. Where hollow micro spheres are used, they are typically present in the range 1-95% v/v, more preferably 5-95% v/v, in particular 50-95% v/v, the foregoing figures referring to the expanded volumes.

The anti-oxidant can be selected from those commonly used in the art. Phenolic anti-oxidants are preferred. The anti-oxidant is typically present in an amount 0.01-1% w/w, for example 0.1-1% w/w.

In a further aspect, the invention provides a composition as hereinbefore defined for use as a cable filler.

5 In another aspect, the invention provides a cable, such as a communications cable, containing a filler as hereinbefore defined.

10 In a still further aspect, the invention provides a cable comprising a conducting core surrounded by a sheath, a composition as hereinbefore defined being disposed between the conducting core and the sheath. The conducting core can be, for example, an electrical conductor or a light conductor. The electrical conductor can be, for example, a conductor for conducting electrical signals such as telephone signals.

15 In a further aspect, the invention provides a process for making a cable comprising a conducting core and a sheath, the process comprising the step of extruding the cable sheath onto the conducting core and interposing a composition as hereinbefore defined between the conducting core and sheath during the extrusion step.

In another aspect, the invention provides a process for preparing a gel as hereinbefore defined; the process comprising:

- 20 (a) heating the oily base to a temperature in the range 110°C to 120°C;
(b) adding the polymeric gelling agent to the oily base and blending to form a mixture;
(c) cooling the mixture to a temperature of less than 90°C;
(d) adding and blending in the micro spheres; and optionally
(e) adding and blending in an anti-oxidant; and/or
25 (f) maintaining the mixture under vacuum to remove entrapped gas.

In a preferred embodiment, the process comprises:

- (i) blending at least one oil in a heating-blending tank;
(ii) heating the blended oils to 110-120°C in a stirred heating-blending tank;
30 (iii) adding and blending the polymeric gelling agent to the oily base under high shear for no more than one hour after transfer of the oily base to a blending-cooling tank, allowing the temperature of the blend to rise to more than 120-130°C;
(iv) cooling the blend to <90°C. and transferring to a stirred main reactor;
(v) adding and blending an anti-oxidant;

- (vi) adding and blending the micro spheres, drawn to the reactor under vacuum or pumping, for at least two minutes;
- (vii) maintaining the vacuum for at least another 10 minutes in order to effect removal of air bubbles prior to release of the finished gel.

5

Although the temperature of the mixture is typically $< 90^{\circ}\text{C}$ after cooling, more preferably it is $< 80^{\circ}\text{C}$, in particular it is $< 70^{\circ}\text{C}$.

10

Further and particular aspects of the invention are as set out in the claims appended hereto.

Brief Description of the Drawings

The invention will now be illustrated, but not limited, by reference to the particular embodiments shown in the accompanying drawings, in which:

15

Figure 1 shows a cross-sectional view of an electrical cable; and

Figure 2 shows a cross-sectional view of an optical cable;

Figure 3 is a graph of viscosity against shear rate for the composition of Example 1 at 25°C ; and

20

Figure 4 is a graph of viscosity against shear rate for the composition of Example 2 at 25°C

Detailed Description of the Preferred Embodiments

Figure 1 shows a cross-sectional view of an electrical cable 11, comprising, in this example, four electrical leads 13 encased in cladding 12. The electrical leads 13 themselves
25 comprise an electrical conductor 14, preferably of copper, and an outer insulation 15, typically of polyethylene. Interspersed between the electrical leads 13 and the outer cladding 12, is a filler gel composition 16. In this embodiment, the filler composition can comprise an oily base, a thermoplastic rubber as polymeric gelling agent and micro spheres dispersed therein and optionally an anti-oxidant. The electrical cable, typically comprising a copper core, can be
30 used for the purposes of telecommunications or distribution of electricity.

Although Figure 1 shows a cross-sectional view of an electrical cable comprising four conductors in a star quad configuration, it will be appreciated that cables having a variety of different configurations can be used as alternatives to the configuration shown.

Figure 2 shows an optical cable 21 comprising three optical fibre buffer tubes 23 encased in cladding 22. The optical fibre buffer tubes 23 themselves consist of an optical fibre 24 provided with a protective coating 26 and a protective sheath 25. The filler composition 27 is disposed between the coated optical fibre and the protective sheath. Additionally, it fills the interstices formed between individual buffer tubes and between the buffer tubes and the internal surface of the cable cladding.

Examples of specific gels suitable for use in cables, such as the cables illustrated in Figures 1 and 2 are as follows:

EXAMPLE 1

A gel filler was prepared having the following composition:

Component	Concentration (% wt.)
White mineral oil SN 500 (Mobil)	89.0
Thermoplastic elastomer Kraton 1701 or 1702 (Shell)	5.5
Micro spheres (pre-expanded) Expancel 091 DE (Triones Chems. Int.)	5.0
Anti-oxidant Irganox L 135 (Ciba-Geigy)	0.5

The gel filler of this example is suitable for filling the interstices between the tubes and conductors (flooding) and is not in direct contact with the fibre guides.

The gel was prepared as follows:

The oily base was introduced into a stirred heating-blending tank and heated to 110-120°C before transferring to a high shear blending-cooling tank, whereupon the thermoplastic elastomer (Kraton) (in the form of granules) was added. The mixture was blended under high shear conditions using a multi-purpose immersion type mixer emulsifier (Silverson Machines Limited, Model GDD 25) for no more than 60 minutes. During the blending process, the temperature of the mixture was allowed to rise to 120-130°C. The mixture was cooled by

means of a cold water chiller system, and the chilled mixture was transferred to a stirred main reactor where the anti-oxidant was added. A vacuum was then created inside the reactor in order to suck in the micro spheres which were mixed into the blend over a period of at least two minutes. The vacuum was maintained for at least a further ten minutes in order to effect removal of any air bubbles. The vacuum was then released, the stirrer switched off and samples taken prior to release of the finished gel from the main reactor.

The product was characterised by a number of tests, the results of which are summarised in Table 1 below. The thermal conductivities referred to in the table were determined as follows:

Specimen discs were created by scooping the gels into a pair of nylon rings of mean internal diameter 70.1 mm and mean thickness 10.03 mm and placing cling film above and below. A small correction was made to allow for the extra interface introduced by the cling film. The thermal conductivity of the specimens was measured using a 76 mm guarded hotplate. A pair of specimen discs were mounted, under the pressure of two cooled plates, on either side of a guarded heater plate. The cooled plates were maintained at a constant temperature to better than $\pm 0.05^\circ\text{C}$. The surfaces of the plates had emittances of better than 0.9. The temperature of the annular guard on the heater plate was matched to that of the central part to better than $\pm 0.01^\circ\text{C}$ in order to minimise lateral heat flow in the specimens. The heater plate and the specimens were insulated with a glass fibre blanket to further reduce edge heat losses. The temperature drop through the specimens was fixed at 14°C and about 5 hours was allowed for thermal equilibrium to be established before final readings were taken.

The aging test was derived from YD/T839.4-1996 (PRC Method) except that the temperature and duration of the test was altered.

Table 1: Physical Properties

	Property	Value	Test Method
	Density (20°C) g/ml	0.356	ASTM D 1475
	Viscosity (100s^{-1} , 25°C) Pa.s	23.63	Haake VT500
	Tube drainage (7mm id/ 80°C /24 hrs.)	Pass	EIA/TIA-455-81A
	Cone Penetration (23°C) dmm	335	ASTM D937
	Cone Penetration (-30°C) dmm	167	ASTM D937
	Cone Penetration (-40°C) dmm	120	ASTM D937
	Oil separation (80°C /24 hrs.) % wt.	0	FTM791(321)

	Volatile loss (80°C/24 hrs.) % w/w	0.17	FTM791(321)
	OIT (190°C) min.	34.75	ASTM D3895
5	Thermal conductivity (23°C) W/m.K	0.077	see above
	Thermal conductivity (80°C) W/m.K	0.078	see above
	Hydrogen generation (80°C/24hrs.) μ l/g	0.010	
	Acid Value mgKOH/g	0.036	BS2000
10	Aging (100°C/240 hrs.)	Pass	see above
	UV exposure (25°C/14 days)	Pass	
	Temperature exposure (240°C/5 mins.)	Pass	

OIT \equiv Oxidative induction time

15

Table 1 shows that the density of the gel is low which contributed to good anti-drip properties (measured at 80°C). Low temperature performance was assessed by cone penetration at -40°C whilst high temperature performance was tested by a combination of the drip test, oil separation and volatile loss tests all carried out at 80°C and the oxidative induction time test carried out at 190°C. An oxidative induction time in excess of 20 minutes is desirable. The results indicate that the gel has a working temperature range of -40 to +80°C. Furthermore the rheological behaviour of the gel, shown in figure 3, is thixotropic (shear thinning) allowing for cold pumping and processing, and thus cable filling in the absence of voids created by gel shrinkage.

25

Thermal conductivity was determined at 23°C and 80°C. The values for the conductivity were low reflecting the low density of the gel, and varied little with temperature suggesting a material possessing a disordered structure. The good insulating properties indicated a material possessing good resistance to thermal decomposition that can occur at the elevated temperatures reached during cable manufacture. In addition, the gel would be less sensitive to the thermal expansion and contraction that can take place during cable manufacture leading to the formation of voids in the cable filling. For purposes of comparison, the thermal conductivities of a range of materials are given in Table 2.

35

Table 2: Thermal Conductivities of Various Materials

Material	Thermal conductivity W/m.K	Comment
Aluminium	200	Very good conductor
Water	0.6	

Olive oil	0.17	
Paraffin	0.15	
Air	0.024	Very good insulator

5 The gel showed good aging properties and uv and temperature resistance. There was also low hydrogen gas generation.

EXAMPLE 2

10 A similar gel filler was prepared in a similar manner to that described in Example 1 but with a different grade of mineral oil. The gel was suitable for use in small pair telephone copper cable filling and flooding applications.

15 The gel was subject to a number of physical tests. The results of the physical tests were similar to those of the composition of Example 1 and therefore only the electrical properties are quoted in Table 3.

Table 3: Physical Properties

	Property	Value	Test Method
20	Dielectric constant (23°C)	1.62	ASTM D924
	Dielectric dissipation factor (1 MHz)	4.4×10^{-4}	ASTM D924
	Volume resistivity (23°C) Ohm.cm	2.8×10^{15}	ASTM D257
	Break down voltage kV	86	

25 The gel is characterised by a low relative permittivity (1.62) and a high volume resistivity (2.8×10^{15} Ohm.cm). For purposes of comparison, the relative permittivities of a number of materials are given in Table 4.

Table 4: Relative Permittivities of Various Materials

	Material	Relative permittivity
30	Air (normal pressure)	1.0005
	Paraffin wax	2
	Paraffin oil	4.7
	Glass	5-10
35	Mica	6
	Methyl alcohol	32

Water

81

EXAMPLE 3

A gel suitable for use in filling loose tubes and interstitial filling between ribbons and open slotted cores, was prepared in a similar manner to that described in example 1. The formula for this gel is set out below:

Component	Concentration (% wt.)
Poly α -olefin oil ^a Durasyn 166 (Amoco)	66.37
White mineral oil Whiterex 250 (BP/Mobil)	22.13
Thermoplastic elastomer Kraton 1701 or 1702 (Shell)	7.5
Micro spheres (pre-expanded) Expancel 091 DE (Triones Chems. Int.)	3.5
Anti-oxidant Irganox L 135 (Ciba-Geigy)	0.5

^a The poly α -olefin oil is also supplied by BP/Mobil as SHF 61

The gel was subject to a number of physical tests. The results of the physical tests, which were similar to the results of the composition of Example 1, are shown in Table 5.

In addition, the tensile strength and coating strip force of optical fibres were tested according to the standards FOTP – 28 and FOTP – 178 respectively. The optical fibre was CPC6 manufactured by Siecor. The tests were carried out after ageing of the fibres in forced air chambers for 30 days at $85 \pm 1^\circ\text{C}$ whilst immersed in the gel. Measurements were carried out at 20°C and 70% relative humidity. The tensile strength was measured on thirty 0.5mm samples from four different groups at a rate of elongation of 500 ± 50 mm/min. 50mm samples were used for the coating strip force tests using a stripping tool at a speed of 500 ± 50 mm/min.

Average tensile strength and coating strip force values for a control sample were 68.89 N and 3.61 N respectively.

Table 5: Physical Properties

Property	Value	Test Method
Density (20°C) g/ml	0.438	ASTM D 1475
Viscosity (200s ⁻¹ , 25°C) Pa.s	7.95	Haake VT500
Tube drainage (7mm id/80°C/24 hrs.)	Pass	EIA/TIA-455-81A
Cone Penetration (23°C) dmm	396	ASTM D937
Cone Penetration (-40°C) dmm	250	ASTM D937
Oil separation (80°C/24 hrs.) % wt.	0	FTM791(321)
Volatile loss (80°C/24 hrs.) % w/w	0.06	FTM791(321)
OIT (190°C) min.	31.04	ASTM D3895
Thermal conductivity (23°C) W/m.K	0.077	see example 1
Thermal conductivity (80°C) W/m.K	0.078	see example 1
Hydrogen generation (80°C/24hrs.) µl/g	0.015	
Relative permittivity (50Hz, 25°C)	1.65	ASTM D150
Volume resistivity (23°C) Ohm.cm	19x10 ¹⁴	ASTM D257
Tensile strength (20 °C/70% RH) N	65.07	FOTP - 28
Coating strip force (20 °C/70% RH) N	3.88	FOTP - 178
Aging (100°C/240 hrs.)	Pass	see example 1
UV exposure (25°C/14 days)	Pass	
Temperature exposure (240°C/5 mins.)	Pass	

OIT ≡ Oxidative induction time

The shear sensitive behaviour of the viscosity is illustrated in Figure 4 and shows that the gel is thixotropic or shear thinning. This gel, although of lower viscosity than the gel of example 1, still passed the drainage test. The low temperature performance, characterised by the cone penetration at -40°C, was exceptional. This is particularly important as this gel is used in direct contact with optical fibres and must maintain flexibility at low temperatures to avoid applying stresses to the aforementioned fibres or micro bending caused by contraction which can lead to an increase in attenuation. The tensile strength and coating strip force results suggested that there was no deterioration in the mechanical strength of the fibres or degradation in the fibre coating after exposure to the gel.

EXAMPLE 4

This gel, formulated for filling loose tubes and interstitial filling between ribbons and open slotted cores particularly for use with polypropylene cable polymers, was prepared in a similar manner to that described in example 1. The formula for this gel is set out below:

Component	Concentration (% wt.)
Silicone oil F111/5000 (Ambersil)	94.7
Fumed silica M5 (Cabot)	1.8
Micro spheres (pre-expanded) Expancel 091 DE (Triones Chems. Int.)	3.0
Cross-linking additive	0.5

The resulting gel was subject to a number of physical and chemical tests, the results of which are summarised in Table 6 below.

The gel was tested for compatibility with polypropylene using the following method:

Six 50mm long samples of buffer loose tubes were weighed to 0.00001g. Five of the samples were subsequently immersed in the gel and all six aged in an air-circulated oven at 80°C for two weeks. The samples were then re-weighed.

Table 6: Physical Properties

Property	Value	Test Method
Density (20°C) g/ml	0.51	ASTM D 1475
Viscosity (100s ⁻¹ , 25°C) Pa.s	32.86	Haake VT500
Tube drainage (7mm id/80°C/24 hrs.)	Pass	EIA/TIA-455-81A
Cone Penetration (23°C) dmm	340	ASTM D937
Cone Penetration (-40°C) dmm	280	ASTM D937
Oil separation (80°C/24 hrs.) % wt.	4.97	FTM791(321)
Volatile loss (80°C/24 hrs.) % w/w	0.11	FTM791(321)
OIT (190°C) min.	33.15	ASTM D3895
Hydrogen generation (80°C/24hrs.) µl/g	0.012	

	Tensile strength (20 °C/70% RH) N	66.00	FOTP - 28
	Coating strip force (20 °C/70% RH) N	4.10	FOTP - 178
5	Aging (100°C/240 hrs.)	Pass	see example 1
	UV exposure (25°C/14 days)	Pass	
	Temperature exposure (240°C/5 mins.)	Pass	
	Polypropylene compatibility (80°C/2 wks.)	Pass	see above

10

OIT \equiv Oxidative induction time

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The results from the low temperature cone penetration, and the oil separation, volatile loss and oxidative induction time experiments suggest that the operating range of this gel is -40 to +80 °C. The tensile strength and coating strip force results suggested that there was no deterioration in the mechanical strength of the fibres or degradation in the fibre coating after exposure to the gel. The gel was found to be compatible with polypropylene as there was no weight gain in the immersed tube samples after aging.

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EXAMPLE 5

This gel, formulated for cable flooding and interstitial filling applications and is a swellable water blocking gel, was prepared in a similar manner to that described in example 1. The formula for this gel is set out below:

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Component	Concentration (% wt.)
White mineral oil SN 500 (Mobil)	89.5
Thermoplastic elastomer Kraton 1701 or 1702 (Shell)	4.0
Fumed silica M5 (Cabot)	3.0
Micro spheres (unexpanded) Expancel 551 DU (Triones Chems. Int.)	2.5

30

Anti-oxidant Irganox L135 (Ciba-Geigy)	0.5
Monopropylene glycol PGUSP-1S (Arco Chemical)	0.5

The gel was subject to a number of physical tests, the results of which are summarised in Table 7 below.

Table 7: Physical Properties

Property	Value	Test Method
Density (20°C) g/ml	0.87	ASTM D 1475
Viscosity (200s ⁻¹ , 25°C) Pa.s	7.00	Haake VT500
Cable drainage (80°C/24 hrs.)	Pass	EIA/TIA-455-81A
Cone Penetration (25°C) dmm	340	ASTM D937
Oil separation (80°C/24 hrs.) % wt.	0	FTM791(321)
OIT (190°C) min.	>40	ASTM D3895
Hydrogen generation (80°C/24hrs) µl/g	<0.02	
Acid Value mgKOH/g	<0.5	BS2000
Tensile strength (20°C/70% RH) N	66.00	FOTP - 28
Coating strip force (20°C/70% RH) N	4.10	FOTP - 178

OIT ≡ Oxidative induction time

The presence of unexpanded hollow micro spheres in the gel meant that the filler increased in volume by 1-10% on heating in the temperature range 95-140°C. Such heat can originate from the extrusion head during manufacture of, for example, fibre optic cables. The swellable nature of the gel can help eliminate voids in the cable created on shrinkage of the cable filler and ensure a watertight seal around the core. The elimination of voids also reduces the likelihood of problems of attenuation associated with fibre optic cables.

The gel can also be used for filling beneath the metallic laminate where over-flooding with petroleum jelly type material can prevent sealing of the overlap whilst under-flooding may create a water path within the cable and lead to the problems of attenuation described above.

It will readily be apparent that numerous modifications and alterations can readily be

made to the compositions exemplified in the Examples without departing from the principles underlying the invention and all such modifications and alterations are intended to be embraced by this application.

CLAIMS

1. A composition which comprises a dispersion of micro spheres in a gel comprising an oily base and an organic polymeric gelling agent.
2. A composition which comprises a dispersion of micro spheres in a gel comprising an oily base and an organic polymeric gelling agent, the composition containing substantially no thixotropic agent other than the organic polymeric gelling agent.
3. A composition which comprises a dispersion of micro spheres in a gel comprising an oily base and a polymeric gelling agent wherein the polymeric gelling agent comprises, consists essentially of, or consists of a thermoplastic elastomer.
4. A composition which comprises a dispersion of micro spheres in a gel comprising an oily base and a polymeric gelling agent wherein the polymeric gelling agent comprises, consists essentially of, or consists of a thermoplastic elastomer other than polystyrene-isoprene rubber.
5. A composition which comprises a dispersion of micro spheres in a gel comprising an oily base and a polymeric gelling agent wherein the polymeric gelling agent comprises, consists essentially of, or consists of a thermoplastic elastomer, excluding compositions containing polystyrene-isoprene rubber and an organic thickener.
6. A composition which comprises a dispersion of micro spheres in a gel comprising an oily base and a thermoplastic elastomer as a gelling agent, the composition containing substantially no thixotropic agent in addition to the thermoplastic elastomer.
7. A gel composition comprising a dispersion of organic microspheres in a gel comprising an oily base and a thermoplastic elastomer, the gel containing substantially no thixotropic agent in addition to the thermoplastic elastomer and being substantially free from silica, for example fumed silica.
8. A composition according to Claim 1 wherein the gel is substantially free of fumed silica.

9. A composition according to any one of claims 1 to 8 which is suitable for use as a cable filler.
- 5 10. A composition according to any one of the preceding claims wherein the oily base comprises at least one oil selected from naphthenic or paraffinic processing oil, mineral oil, synthetic oils such as a poly(α -olefin) synthetic oil and silicone oil.
- 10 11. A composition according to any one of the preceding claims wherein the oily base is present in an amount in the range from 1 to 99% by weight of the composition.
12. A composition according to Claim 11 wherein the oily base is present in an amount in the range from 50 to 99% by weight of the composition, for example in the range 80-99% by weight of the composition.
- 15 13. A composition according to any one of the preceding claims wherein the polymeric gelling agent is a thermoplastic rubber.
- 20 14. A composition according to any one of the preceding claims wherein the polymeric gelling agent is present in an amount in the range 1-10% by weight of the composition, for example in the range 2-9% by weight of the composition, preferably in an amount in the range 3-8% by weight of the composition.
- 25 15. A composition according to any one of the preceding claims containing one or more anti-oxidants.
16. A cable, such as a communications cable, containing as a filler a composition as defined in any one of claims 1 to 15.
- 30 17. A cable comprising a conducting core surrounded by a sheath, a composition as defined in any one of claims 1 to 15 being disposed between the conducting core and the sheath.
18. A cable according to claim 16 or claim 17 wherein the conducting core is an electrical conductor or a light conductor.

19. A process for making a cable comprising a conducting core and a sheath, the process comprising the step of extruding the cable sheath onto the conducting core and interposing a composition as defined in any one of claims 1 to 14 between the conducting
5 core and sheath during the extrusion step.
20. A process for preparing a composition as defined in any one of Claims 1 to 15; the process comprising:
- (a) heating the oily base to a temperature in the range 110°C to 120°C;
 - 10 (b) adding the polymeric gelling agent to the oily base and blending to form a mixture;
 - (c) cooling the mixture to a temperature of less than 90°C;
 - (d) adding and blending in the micro spheres; and optionally
 - (e) adding and blending in an anti-oxidant; and/or
 - 15 (f) maintaining the mixture under vacuum to remove entrapped gas.
21. A process for manufacturing a composition according to any one of Claims 1 to 15 which process comprises:
- (i) blending at least one oil in a heating-blending tank,
 - 20 (ii) heating the blended oils to 110-120°C. in a stirred heating-blending tank,
 - (iii) adding and blending the polymeric gelling agent to the oily base under high shear for no more than one hour after transfer of the oily base to a blending-cooling tank, allowing the temperature of the blend to rise to more than 120-130°C,
 - 25 (iv) cooling the blend to <90°C. and transferring to a stirred main reactor,
 - (v) adding and blending in an anti-oxidant package,
 - (vi) adding and blending the micro spheres, drawn to the reactor under vacuum or pumping, for at least two minutes,
 - (vii) maintaining the vacuum for at least another 10 minutes in order to effect
30 removal of air bubbles prior to release of the finished composition.
22. A composition substantially as described herein with reference to the examples.

1/2

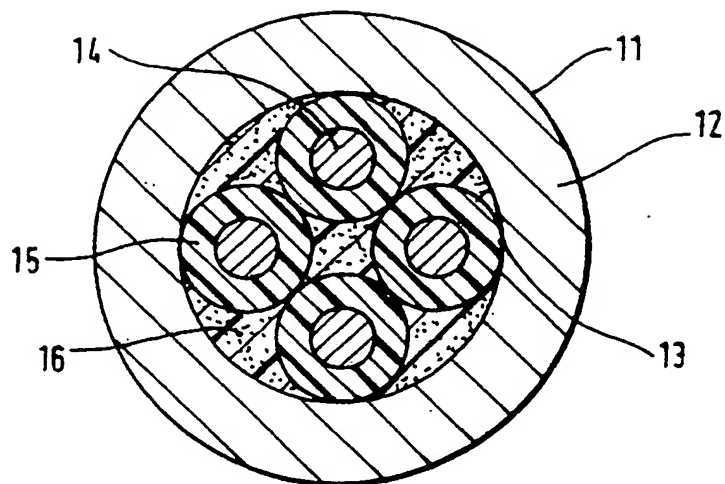


Fig.1.

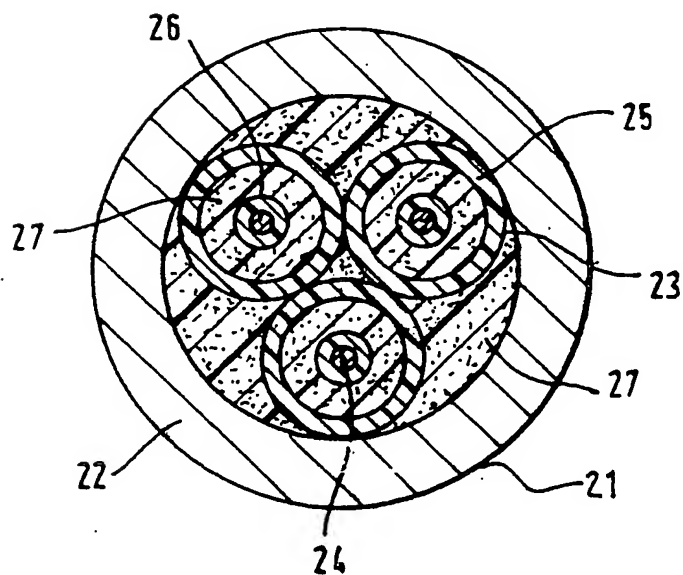


Fig.2.

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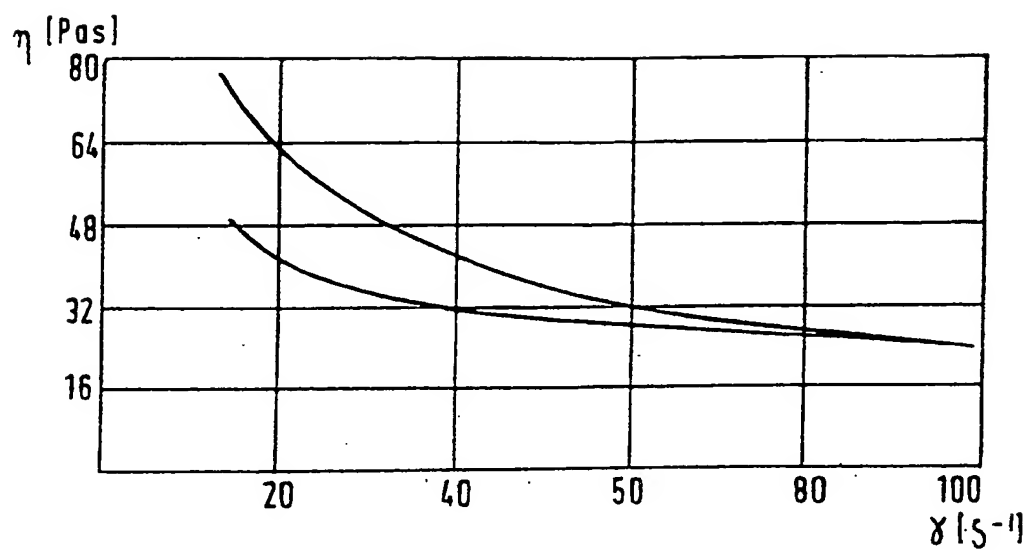


Fig.3.

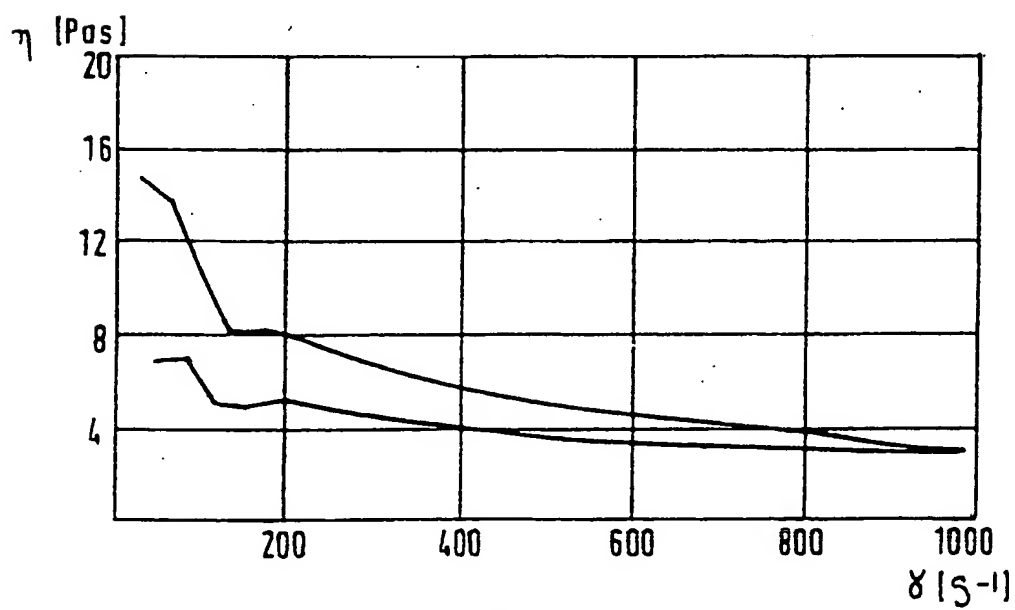


Fig.4.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 01/01428

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B01J13/00 H01B7/28 G02B6/44 C08J9/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01J H01B G02B C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	the whole document	20-22
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	-/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

6 September 2001

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International Application No

PC1/GB 01/01428

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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